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# Procedure Selecting Pumps Running as Turbines in Micro Hydro Plants

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**Abstract**

The authors present a combined method using statistical and numerical models for selecting a pump running as turbine in micro hydro plants. The data of the site (head and capacity) allow calculating two coefficients, $C_Q$ and $C_H$, which identify the pump to use successfully as turbine in that place. A one dimensional model, starting from data available on the pumps manufacturers catalogues, reconstructs a virtual geometry of the PAT, then calculates the performances curves, head vs. capacity, efficiency vs. capacity. The procedure has been applied with the aim to select a PAT recovering energy from a pipeline whose characteristic curve is known.


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## 1. Introduction

In the last years, the request of energy from renewable resources has increased more and more tacking into account the depletion of traditional sources like oil, gas, nuclear [1]. Wind, sun, tides, rivers offer huge quantities of clean, green and renewable energy. Among these, hydraulic sources are the most easily used and their exploitation is always desirable. However, small resources, under 100 kW, often are not considered or discarded, because of the

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specific cost of energy, which is higher respect to that of big hydro-electrical power plants. The traditional turbines are very expensive and their cost can reach the 25% of the entire plant one. Moreover, they need specific maintenance and have components hardly available on the market. The pumps working as turbines (PATs) [2] constitute an alternative surely cheaper and manageable. Centrifugal pumps are mass-produced for a wide range of heads and flow rates so their prime cost is lower than that of the turbine and their maintenance is easier, because of the availability of spare parts, even in developing countries. The efficiency of these machines will be lower but, as they exploit otherwise wasted energy sources, this is not a critical issue. From the economic point of view, realizing a micro hydro plant using PATs having power up to 500 kW, imply payback periods less than two years [3], surely lower with respect to installations using conventional turbines.

This work is framed in this context, with the goal to find the performance curves of a PAT suitable to a hydrological site, whose head $H_{site}$ and capacity $Q_{site}$ are known. To do this, the authors propose a procedure, which involves a statistical method and a numerical model.

The statistic method allows calculating two conversion factors [4]: $C_Q$ as ratio between the capacity of the pump running as turbine and that of the pump one at best efficiency point (BEP) and $C_H$ as ratio between the two heads, defined in a similar way. Both the coefficients are expressed in relation with $n_{sp}$, the specific speed of the PAT working in pump mode, which can be expressed as function of that of the same machine working as turbine $n_{st}$. This last parameter can be obtained from the hydrological data of the site $H_{site}$ and $Q_{site}$, unique input data known when the selection of the PAT has to be done. Once calculated head and capacity at BEP of the pump suitable for the chosen site, it is possible to select, on the composite performance chart of the manufacturer, the pump one.

The authors propose a numerical model, developed during the past years [5-6], which is able to estimate the performance of the chosen pump in the reverse mode, as turbine (PAT).

Firstly, the code reconstructs the geometrical parameters of the PAT, which usually are unknown, by using information provided on the manufacturer catalogue. Once deduced these data, the code calculates the losses and determines the characteristics curves of the PAT i. e. head vs. capacity and efficiency vs. capacity. The knowledge of such curves allows the operating point of the plant to be assessed. In this way, the annual yield of energy can be estimated. The case study of a pipeline whose characteristic curve is known is presented with the aim to better expose the proposed methodology.

## 2. Statistical Model

The main issue using PATs is represented by the choice of the machine because the performance curves of a pump running as turbine are not immediately available. In fact, on the catalogues of the pumps manufacturer the only performances of the pump operations are reported. Therefore, it is important to connect the pump performances to the turbine performances of the same machine, by using mathematic correlations having universal validity and involving simple data obtainable from the pump catalogue. The easiest way to pass from the pump working mode to the turbine working mode is to put in relation the best efficient point (BEP) of the pump to that of the turbine. In this way two coefficients can be detected: the best head ratio and the best flow rate ratio. Childs [7], Sharma [8], Alatorre [9] and Stepanoff [10] link these coefficients to the global efficiency of the pump. Hancock [11] links them to the global efficiency of the turbine while Schmield [12] relates them to the hydraulic efficiency of the pump.

Some authors, like Grover [13] and Hergt [14], consider statistic correlations involving the specific speed of the pump by considering that the shape of the impeller, and consequently the losses typology, changes when the specific speed increases, as showed in Fig. 1.

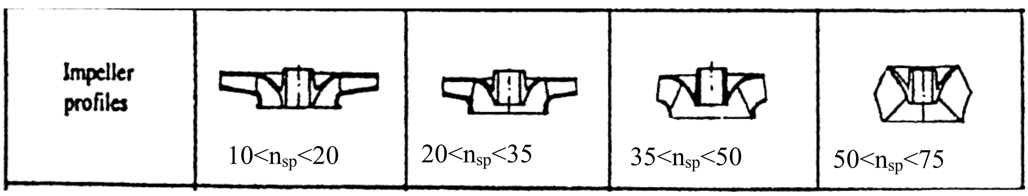


Fig. 1. Shape of the impeller with $n_{sp}$ increasing